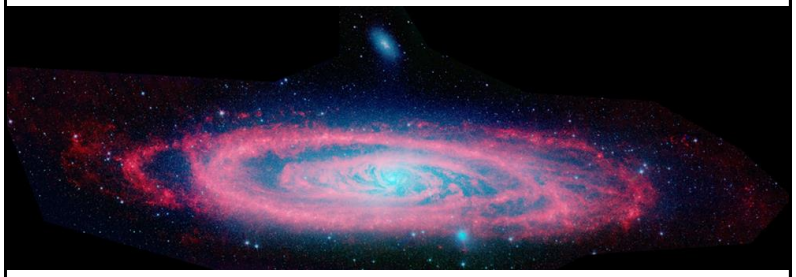
Chapter 1 -- INTRODUCTION: THE NATURE OF SCIENCE AND PHYSICS



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Science

Science seeks to discover and describe the underlying order and simplicity in nature (your environment; objects).

↓

Objects have properties unique to that given object (e.g., size, color, density, mass…)

↓

Taking measurements makes the collection of data more precise. Units are standards for expressing and comparing the measurement of physical quantities. All units can be expressed as combinations of four fundamental units (meter, Kg, sec, and amps).

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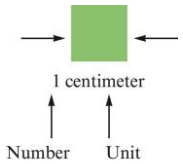
Quantifying Properties: ***Measurements***

- Measurement— numerical value with units
  ex- 6.003 grams



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Unit Conversion

A conversion factor is a ratio that expresses how many of one unit are equal to another unit. Conversion factors can be used to convert between unit systems or to convert to different between units in the same unit system.

$$20\ \text{ft} = 20\ \text{ft} \times \frac{1\ \text{yd}}{3\ \text{ft}} = 6.7\ \text{yd}$$

$$50\ \text{mph} = \frac{50\ \text{mi}}{1\ \text{hr}} \times \frac{1\ \text{hr}}{3600\ \text{s}} \times \frac{1609\ \text{m}}{1\ \text{mi}} = 22.3\ \text{m/s}$$

$$1\frac{\text{g}}{\text{cm}^3} = \frac{1\ \text{g}}{1\text{cm}^3} \times \frac{1\ \text{kg}}{1000\ \text{g}} \times \left(\frac{100\ \text{cm}}{1\ \text{m}}\right)^3 = 1000\ \text{kg/m}^3$$

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1.2 Physical Quantities and Units

1. The speed limit on some interstate highways is roughly 100 km/h. (a) What is this in meters per second? (b) How many miles per hour is this?

2. A car is traveling at a speed of $33\ \mathrm{m/s}$. (a) What is its speed in kilometers per hour? (b) Is it exceeding the $90\ \mathrm{km/h}$ speed limit?

3. Show that $1.0\ \mathrm{m/s} = 3.6\ \mathrm{km/h}$. Hint: Show the explicit steps involved in converting $1.0\ \mathrm{m/s} = 3.6\ \mathrm{km/h}$.

4. American football is played on a 100-yd-long field, excluding the end zones. How long is the field in meters? (Assume that 1 meter equals 3.281 feet.)

5. Soccer fields vary in size. A large soccer field is 115 m long and 85 m wide. What are its dimensions in feet and inches? (Assume that 1 meter equals 3.281 feet.)

6. What is the height in meters of a person who is 6 ft 1.0 in. tall? (Assume that 1 meter equals 39.37 in.)

7. Mount Everest, at 29,028 feet, is the tallest mountain on the Earth. What is its height in kilometers? (Assume that 1 kilometer equals 3,281 feet.)

8. The speed of sound is measured to be $342\ \mathrm{m/s}$ on a certain day. What is this in km/h?

9. Tectonic plates are large segments of the Earth's crust that move slowly. Suppose that one such plate has an average speed of 4.0 cm/year. (a) What distance does it move in 1 s at this speed? (b) What is its speed in kilometers per million years?

10. (a) Refer to **Table 1.3** to determine the average distance between the Earth and the Sun. Then calculate the average speed of the Earth in its orbit in kilometers per second. (b) What is this in meters per second?

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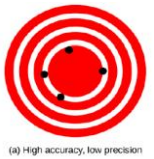
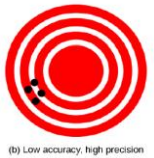
Accuracy and Precision of a Measurement

Accuracy is how close a measured value is to its accepted reference value.

Precision is how close repeated independent measurements are to one another. A set of measurements can be precise, accurate, neither, or both.



(a) High accuracy, low precision



(b) Low accuracy, high precision

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Accuracy and Precision of a Measurement

Accuracy is how close a measured value is to its accepted reference value.

(a) High accuracy, low precision

uncertainty in this value | Experimental- True value |

$$\% \text{ unc} = \frac{\delta A}{A} \times 100\%.$$

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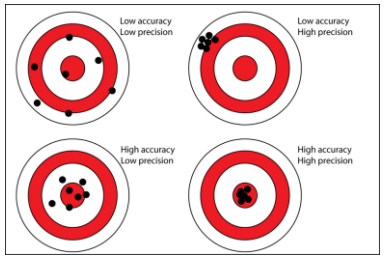
Accuracy and Precision of a Measurement

Precision is how close repeated independent measurements are to one another. A set of measurements can be precise, accurate, neither, or both.

(b) Low accuracy, high precision

Precision Range = Highest Value – Lowest Value



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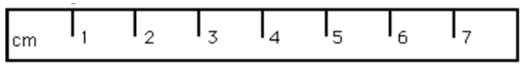
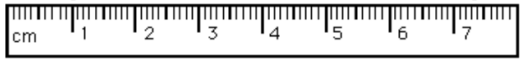
Uncertainty and Significant Figures

- Uncertainty
  - Associated with any measured value



absolute uncertainty is 1 cm.

± 1 cm



absolute uncertainty is 0.1 cm

± 0.1 cm

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Uncertainty and Significant Figures

- Electronic instruments

34.04 secs

absolute uncertainty is 0.01 sec

±0.01 sec

absolute uncertainty is 0.001 sec

±0.001 sec

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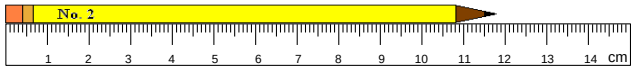
Uncertainty and Significant Figures

What is the uncertainty of the ruler shown here?



±0.1 cm

about 11.8 cm ±0.1 cm

11.7 cm or 11.9 cm

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Chapter 1.2 –Significant Figures

Measurement

- Quantitative observation consisting of two parts.
  - Number
  - Unit

- Examples
  - 20 grams
  - 6.63×10^{-34} joule·seconds

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Significant Figures

The number of **significant figures** in a measured quantity is equal to the number of non-zero digits plus the number of zeros not at the beginning of the quantity. For example, 1.300 has four significant figures and 1.05 has three significant figures, but 0.053 has only two significant figures.

When adding or subtracting, keep only the number of decimal places of the number with the least precision. When multiplying or dividing, keep only the number of significant figures of the number with the fewest significant figures.

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Rules for Counting Significant Figures

1. Nonzero integers always count as significant figures.
   - 3456 has 4 sig figs (significant figures).

2. Zeros

- There are three classes of zeros.

a. Leading zeros are zeros that precede all of the nonzero digits. These **never** count as significant figures.
   - 0.048 has 2 sig figs.

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Rules for Counting Significant Figures

b. Captive zeros are zeros that fall between nonzero digits. These **always** count as significant figures.
   - 16.07 has 4 sig figs.

c. Trailing zeros are zeros at the right end of the number (non zero). They **are** significant only if the number contains a decimal point.
   - 9.300 has 4 sig figs.
   - 150 has 2 sig figs. (place holder zeros)

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How many Significant Digits?

74293

5 significant digits

230800

4 significant digits

100000

1 significant digit

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Significant Practice

60020300	6 s.d.	320000	2 s.d.
12.00500	7 s.d.	8900.	4 s.d.
0.0005	1 s.d.	0.0061000	5 s.d.
0.10046	5 s.d.	0.1528	4 s.d.

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Exact numbers

- Exact numbers do NOT take part in significant digits
  Ex:
  1000 mL = 1 L is an exact value

  2.54 cm = 1 inch is an exact value

  24 hours = 1Day

  - Have NO uncertainty because these numbers are DEFINED
  - Will never affect "significant figures

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Exact numbers

Counted numbers are exact numbers:

Ex:
I have 10 fingers

there are 11 dogs

They also have no uncertainty
Will never affect "significant figures"

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Rounding Off Nonsignificant Digits

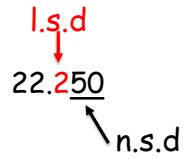
Rules:

1— If the first n.s.d. is 4 or less, leave the l.s.d. alone and drop all n.s.d.
2— If the first n.s.d. is 5 or more, add 1 to the l.s.d. and drop n.s.d.
3— In your calculator, retain all s.d. until last operation

l.s.d = last significant digit
n.s.d. = non significant digit

- Ex: Round off to 3 significant digits

(a) 22.250
(b) 0.34548
(c) 0.072038
(d) 12,267



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Rounding Off Nonsignificant Digits

1— If the first n.s.d. is 4 or less, leave the l.s.d. alone and drop all n.s.d.
2— If the first n.s.d. is 5 or more, add 1 to the l.s.d. and drop n.s.d.
3— In your calculator, retain all s.d. until last operation

0.00259428 (3 s.d.) = 0.00259

54.3675701 (5 s.d.) = 54.368

8265391000 (2 s.d.) = 8300000000

0.1659822 (4 s.d.) = 0.1660 = ~~0.166~~

0.0005473300 (5 s.d.) = 0.00054733

2617890100 (6 s.d.) = 2617890000

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Adding and Subtracting Measurements

- Your final answer is limited by the number with the ***fewest decimal places***.
  Round off your final answer based on the number with the fewest decimal places

7 decimal places

$$\begin{array}{r} 0.0025647 \\ +0.000321 \\ \hline 0.0028857 \end{array} = 0.002886$$

6 decimal places

answer can only be precise to the 6th decimal place

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Adding and Subtracting Measurements

More examples:

106.7	g	5	g		
0.25	g	5.0	g	35.45	mL
+ 0.195	g	+ 5.00	g	- 30.5	mL
107.145	g	15.00	g	4.95	mL

107.1 g 15 g 5.0 g

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Some More Practice

23.67 – 75	-51
5502.8 + 24.691 + 0.01	5527.5
0.109 + 0.09 – 0.955	-0.76
20.4 + 1.322 + 78	100.
0.000004 + 11.23115	11.23115
5449000 + 162211	5611000

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Multiplying and Dividing Measurements

- When multiplying or dividing measurements, the answer is limited by the value with the ***least number of significant digits***.
- Ex:

$$5.15\ \text{cm} \times 2.3\text{cm} = 11.845\ \text{cm}^2$$

$12\ \text{cm}^2$

$$\frac{103.37\ \text{g}}{20.5\ \text{mL}} = 5.0424\ \text{g/mL}$$

$= 5.04\ \text{g/mL}$

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Calculations with Sig. Figs.

927.381 / 456.0 = 2.033730263 = 2.034

6 s.d. 4 s.d.

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Calculations with Sig. Figs.

0.00159 / 2 = 0.000795 = 0.0008

3 s.d. 1 s.d.

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Working with measurements

Key Steps:

1. Record the measurements carefully.
2. Repeat the measurement to increase its reliability, then calculate the average or mean as the "best value"
3. Establish the probable limits of uncertainty
   - Precision Range = Highest Value – Lowest Value
   - Accuracy: Deviation from true value

• Accuracy is often reported as percent error:

$$\text{Percent Error} = \frac{|\text{Experimental Value} - \text{Accepted Value}|}{\text{Accepted value}} \times 100\%$$

• Keep track of significant figures.

Do not write a reading of 50.00 mL as 50 mL or as 50.000 on your worksheet

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Quiz- outline

Chapter 1:

1. Scientific method
2. Metric System, Dimensional Analysis
3. Accuracy, percent error

$$\frac{|\text{Experimental Value} - \text{Accepted Value}|}{\text{Accepted value}} \times 100\%$$

- Significant figures.
  - Rules for Counting Significant Figures
  - Exact numbers
  - Rounding Off Nonsignificant Digits
  - Adding and Subtracting Measurements
  - Multiplying and Dividing Measurements

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worksheet

Chapter 1:

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